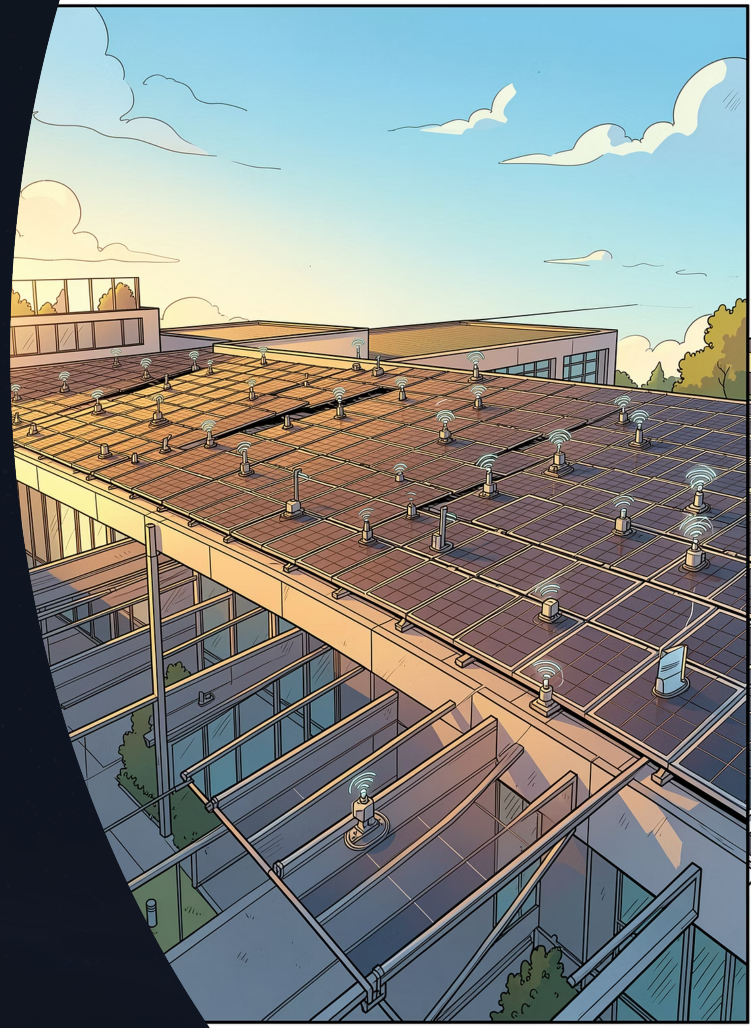
AL-AZHAR UNIVERSITY

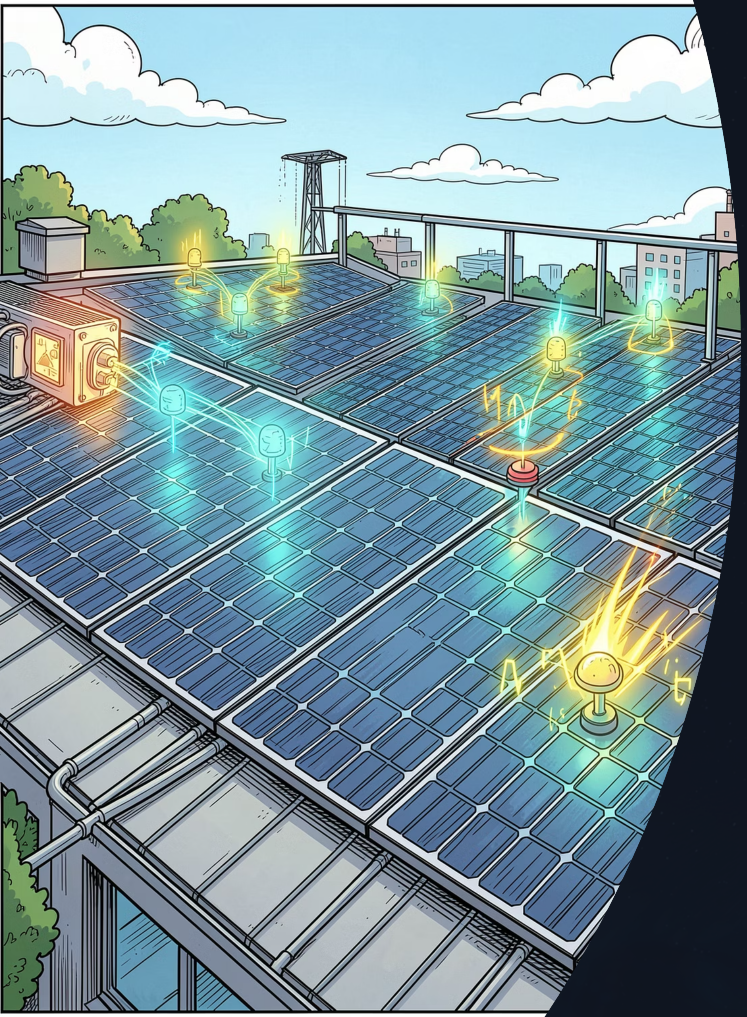
FACULTY OF ENGINEERING

# Building Ad Hoc Networks Using Wireless Sensor Networks

B.Sc. Graduation Project — Electrical Engineering Department

Supervised by Prof. Abdellatif I. Moustafa · July 2026





# Project Vision

Solar PV/T panels degrade silently without warning. This project designs a wireless monitoring system tracking electrical and thermal parameters in real time.

**NI WSN-9791**

Central gateway

**NI WSN-3212**

Thermocouple node

**NI WSN-3202**

Voltage/current node

**LabVIEW + Telegram**

Visualization & alerts

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CHAPTER 1

# Network Fundamentals

From definitions to topologies — the foundation of interconnected systems.

## Network Types

LAN, MAN, and WAN — scaling from a single building to the globe.

## Topologies

Star, Mesh, Ring, Bus, and Point-to-Point arrangements.

## OSI & TCP/IP

Seven-layer reference model vs. four-layer internet suite.

## Network Devices

Hubs, switches, routers, modems, firewalls, and access points.

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CHAPTER 2

# Wireless Sensor Networks

Distributed autonomous sensor nodes collecting environmental data and relaying it wirelessly to a base station.

1

## Environmental

Forest fire detection, flood monitoring, air quality

2

## Healthcare

Wearable vital signs, remote patient monitoring

3

## Agriculture

Soil moisture, automated irrigation, crop health

4

## Industrial

Predictive maintenance, structural health monitoring

5

## Military

Battlefield surveillance, border monitoring

6

## Smart Cities

Traffic, lighting, waste management, parking

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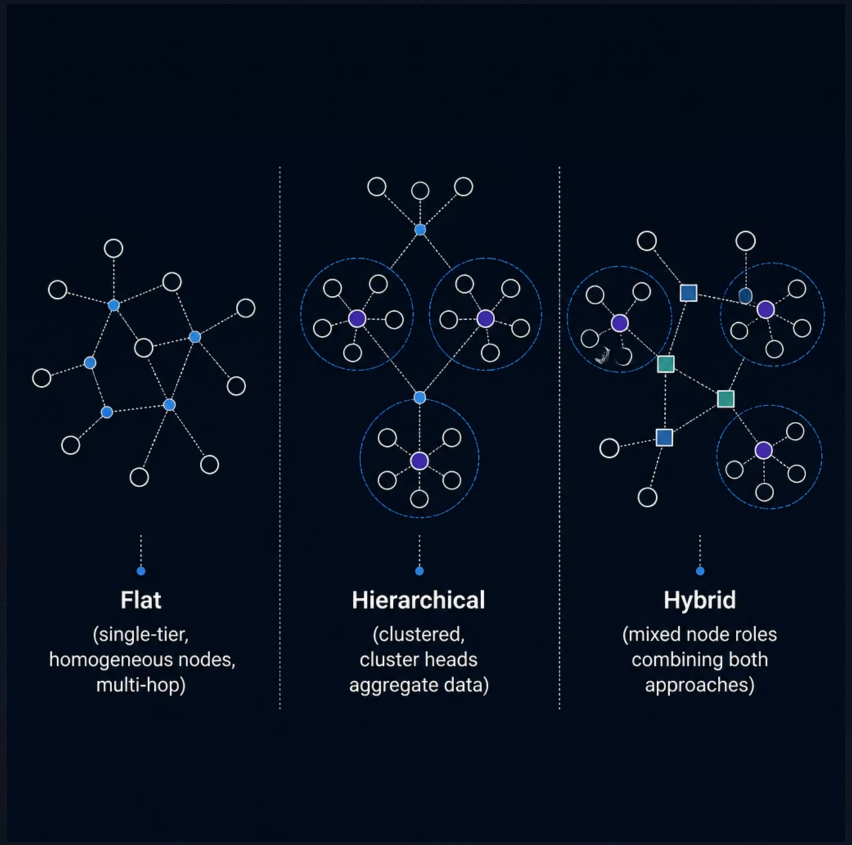
CHAPTER 2

# WSN Architecture & Data Flow




### Three Architectures

- **Flat** — equal nodes, multi-hop routing, energy hole risk
- **Hierarchical** — cluster heads aggregate, LEACH rotation
- **Hybrid** — heterogeneous nodes, flexible trade-off

### Data Flow Stages

Sensing → Local Processing → Multi-hop Routing → Aggregation → Base Station Delivery

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CHAPTER 3

# LabVIEW Integration

Graphical programming platform for data acquisition, real-time visualization, and alarm management.

### Front Panel

GUI with charts, gauges, LEDs

### Block Diagram

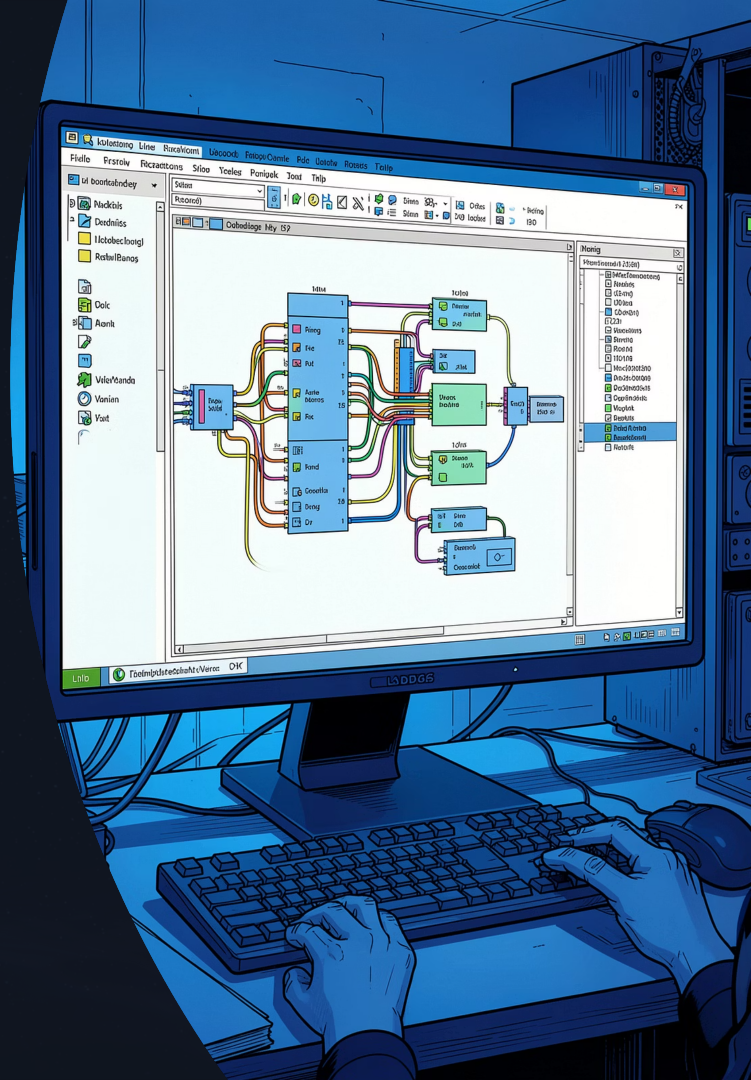
Graphical G code, dataflow logic

### DAQ Pipeline

Receive → Parse → Convert → Log

### Signal Processing

Filtering, FFT, statistical analysis



CHAPTER 4

# Problem Formulation

Translating PV/T monitoring requirements into a rigorous mathematical model.

### Objective 1

Maximize network lifetime

### Objective 2

Minimize energy consumption

### Objective 3

Maximize data reliability

---

### Energy

Battery capacity & duty cycle limits

### Communication

Range, hop count, channel capacity

### Sampling

Interval bounds, thermal time constant

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CHAPTER 5

# System Implementation

From LabVIEW project creation to live multi-node monitoring with Telegram alerts.

**Configure Gateway**

**Develop VI**

**Deploy Nodes**

**Trigger Alerts**

NI WSN-9791 gateway connects to NI WSN-3212 (thermocouple) and NI WSN-3202 (voltage/current) nodes, with LabVIEW Host Controller VI managing alarms and Telegram notifications.

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NI-WSN9791-019DE52A - Measurement & Automation Explorer

File Edit View Tools Help

My System
- Data Neighborhood
- Devices and Interfaces
- Scales
- Software

Remote Systems
- NI-WSN9791-019DE52A

Restart | Save | Refresh | Add Node | Remove Node | Configure Node | Update Firmware | Cancel | Set Permissions | Log In | Hide Help

Wireless 12

| Node Type | Serial Number | ID | Last Communication Time | Battery State | Link Quality | Network Mode | Firmware Version |
|---|---|---|---|---|---|---|---|
| NI WSN-3212 | 199F09A | 2 | 1/1/1904 3:03:21 AM | OK | Excellent | End Node | NI WSN-3212 1.4.0f0 |
| NI WSN-3202 | 1A239FF | 1 | | | | | |

System Settings | Network Settings | WSN Nodes | Gateway Firmware

Back

## LabVIEW Real-Time Target Configuration

Complete the following steps to configure your remote system for use with the LabVIEW Real-Time Module. For a more complete explanation of these steps, refer to the LabVIEW Real-Time Target Configuration Tutorial.

1. **Boot into LabVIEW Real-Time**
2. **Configure Network Settings**
3. **Install Software**
4. **Configure I/O**
5. **Configure System Settings**
6. **Configure Time Settings**
7. **Transfer User Files**

When you complete these steps, your remote system is ready to be targeted from LabVIEW Real-Time.

Submit feedback on this topic.

Visit ni.com/support for technical support.

## WSN Node Configuration

The **WSN Node Configuration** specifies the configuration information for each node in your system.

- **Node Type**
- **Serial Number**
- **ID**
- **Last Communication Time**
- **Battery State**
- **Link Quality**
- **Network Mode**
- **Firmware Version**

Connected - Running

Search

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LabVIEW

File Operate Tools Help

NATIONAL INSTRUMENTS LabVIEW 2013

Search

Create Project

Blank Project

Blank VI

Open Existing

Show All

WSN_Builiding.lvproj

D:\Fourth\WSN_pdf\Project_LabV\Untitled Project 1.lvproj

D:\Fourth\WSN_pdf\Untitled Project 1.lvproj

Analog Input.lvproj

Thermocouple Input.lvproj

9791 Project.lvproj

C:\Users\Mohamed Saeed\OneDrive\Desktop\New folder (2)\WebApplication.lvproj

C:\Users\Mohamed Saeed\OneDrive\Desktop\WebApplication.lvproj

Thermocouple Input (with TDMS).lvproj

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Host Controller VI.vi

thermo.vi

C:\Users\Mohamed Saeed\OneDrive\Desktop\Bot_Telegram\Thermocouple Input.vi

BOOOt.vi

D:\LabView\LabVIEW 2013\examples\NI-WSN\General\Thermocouple Input\Thermocouple Input.vi

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C:\Users\Mohamed Saeed\OneDrive\Desktop\Untitled 2.vi

Untitled 3.vi

WSNReading2.vi

**Find Drivers and Add-ons**
Connect to devices and expand the functionality of LabVIEW.

**Community and Support**
Participate in the discussion forums or request technical support.

**Welcome to LabVIEW**
Learn to use LabVIEW and upgrade from previous versions.

LabVIEW News

Search

ENG

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6/23/2026

Create Project

**Choose a starting point for the project:**

- All
- Templates
- Sample Projects

**Blank Project** *Templates*
Creates a blank project.

**Blank VI** *Templates*
Creates a blank VI.

**Simple State Machine** *Templates*
Facilitates defining the execution sequence for sections of code. **More Information**

**Queued Message Handler** *Templates*
Facilitates multiple sections of code running in parallel and sending data between them. **More Information**

**Actor Framework** *Templates*
Creates an application that consists of multiple, independent tasks that communicate with each other. This template makes extensive use of LabVIEW classes. **More Information**

**Finite Measurement** *Sample Projects*
Acquires a finite measurement and provides options for exporting the measurement to disk. This sample project is based on the Simple State Machine template. **More Information**

**Continuous Measurement and Logging** *Sample Projects*
Acquires measurements continuously and logs them to disk. This sample project is based on the Queued Message Handler template. **More Information**

**Feedback Evaporative Cooler** *Sample Projects*
Implements an evaporative cooler with hot-swappable hardware, controllers, and user interfaces. This sample project is based on the Actor Framework template. **More Information**

**Instrument Driver Project** *Templates*
Creates an instrument driver.

Additional Search
Keyword

Finish Cancel Help

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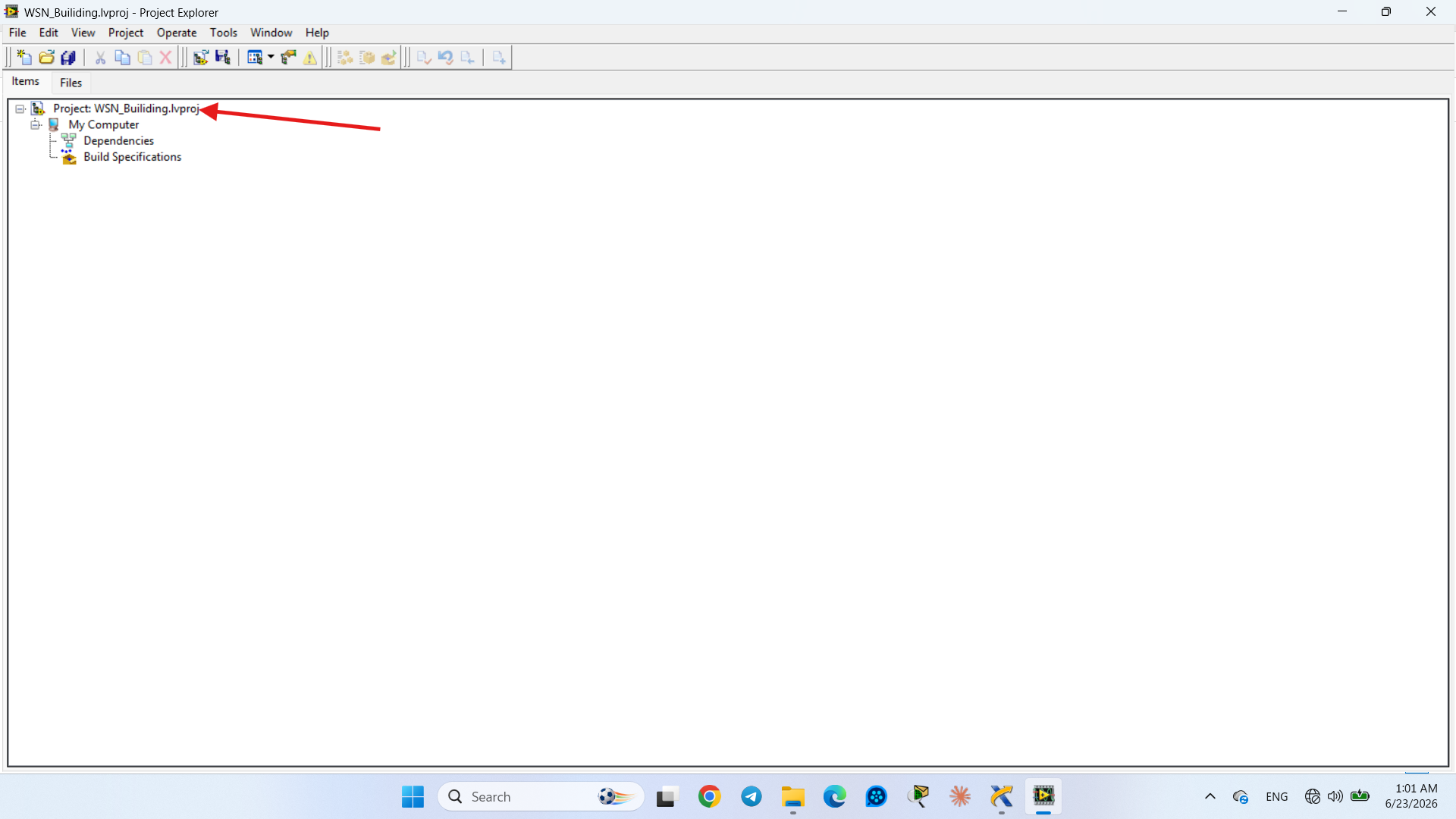
WSN_Builiding.lvproj - Project Explorer
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My Computer
Dependencies
Build Specifications
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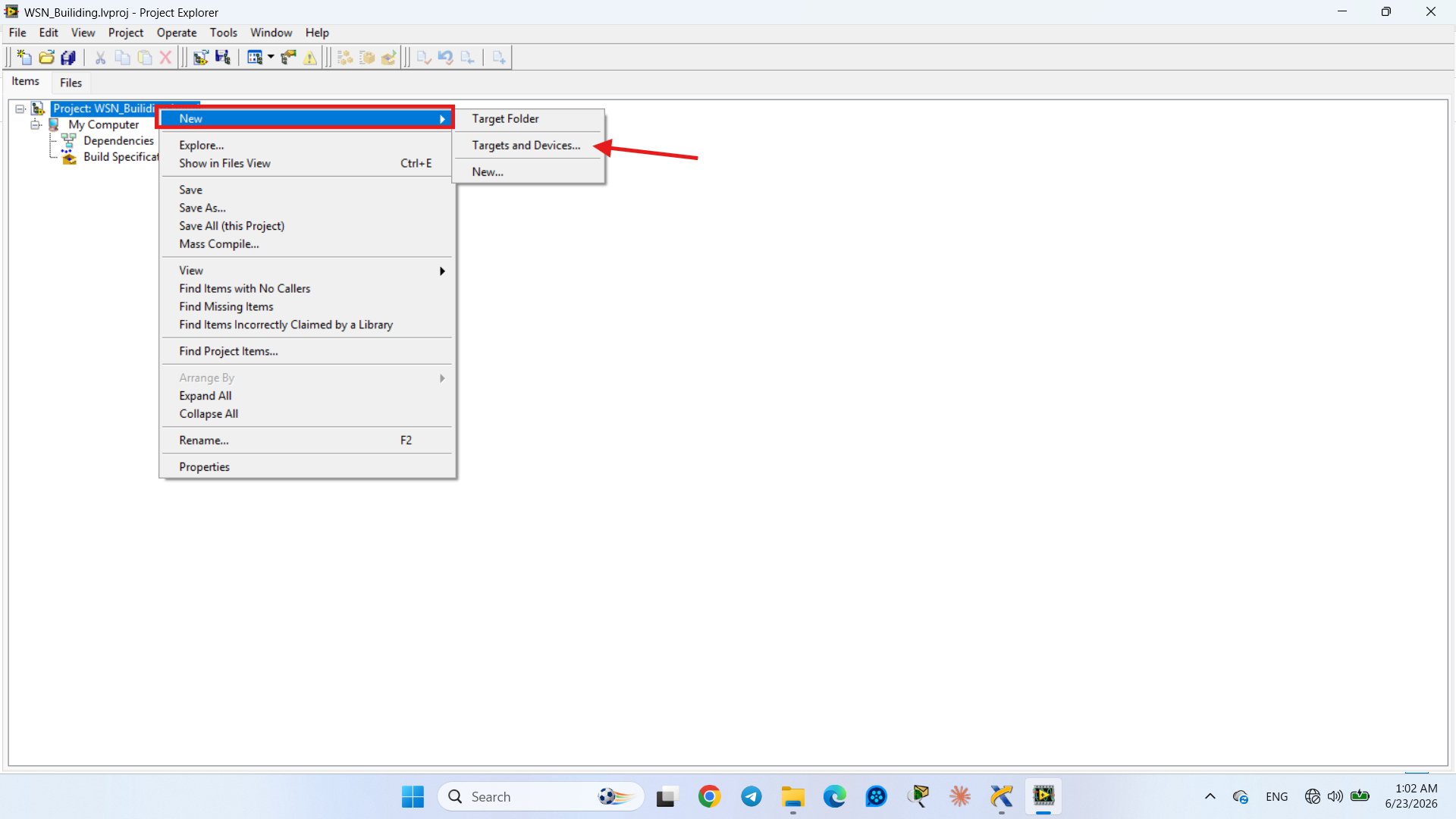
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Save
Save As...
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View
Find Items with No Callers
Find Missing Items
Find Items Incorrectly Claimed by a Library
Find Project Items...
Arrange By
Expand All
Collapse All
Rename... F2
Properties
Target Folder
Targets and Devices...
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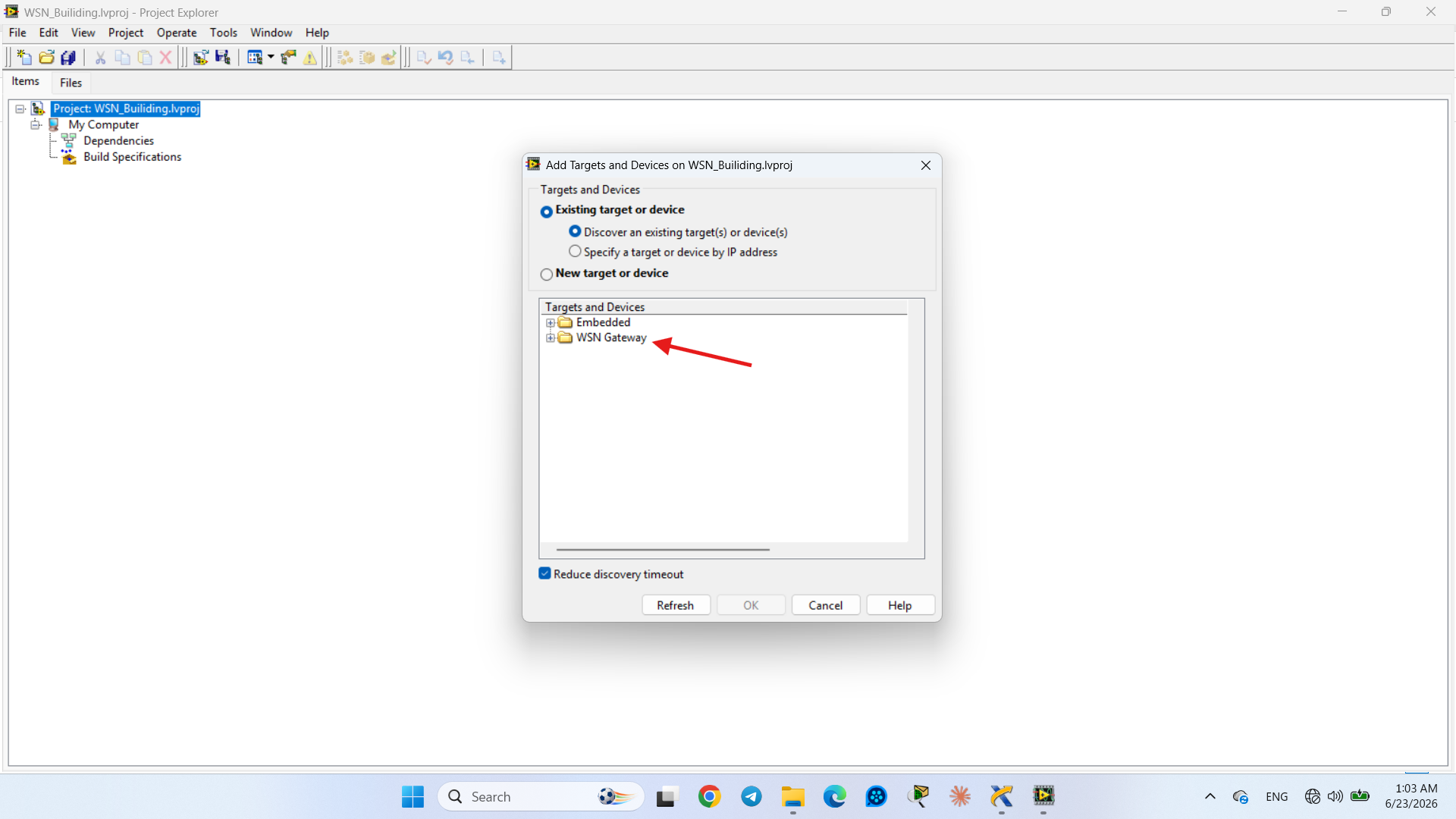
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Items Files
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Build Specifications
Add Targets and Devices on WSN_Builiding.lvproj
Targets and Devices
Existing target or device
Discover an existing target(s) or device(s)
Specify a target or device by IP address
New target or device
Targets and Devices
Embedded
WSN Gateway
Reduce discovery timeout
Refresh
OK
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Help
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WSN_Builiding.lvproj * - Project Explorer

File Edit View Project Operate Tools Window Help

Items Files

- Project: WSN_Builiding.lvproj
  - My Computer
    - Dependencies
    - Build Specifications
  - NI-WSN9791-019DE52A (169.254.11.67)
    - Wireless Sensor Network
      - Node2 (ID 2, 199F09A, NI WSN-3212)

Search

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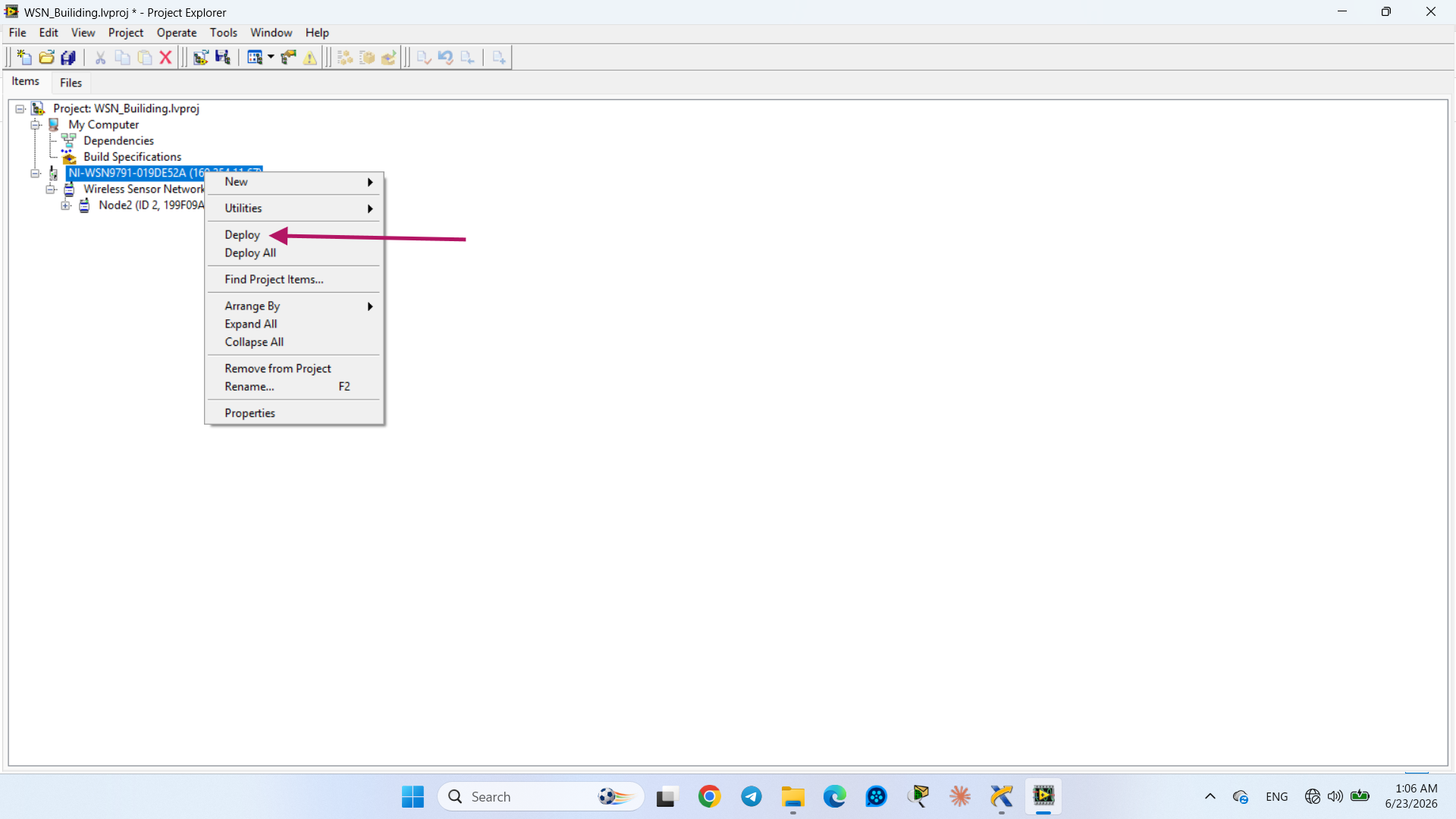
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Wireless Sensor Network
Node2 (ID 2, 199F09A
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Find Project Items...
Arrange By
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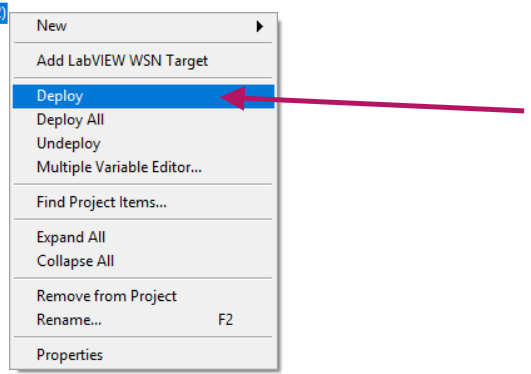


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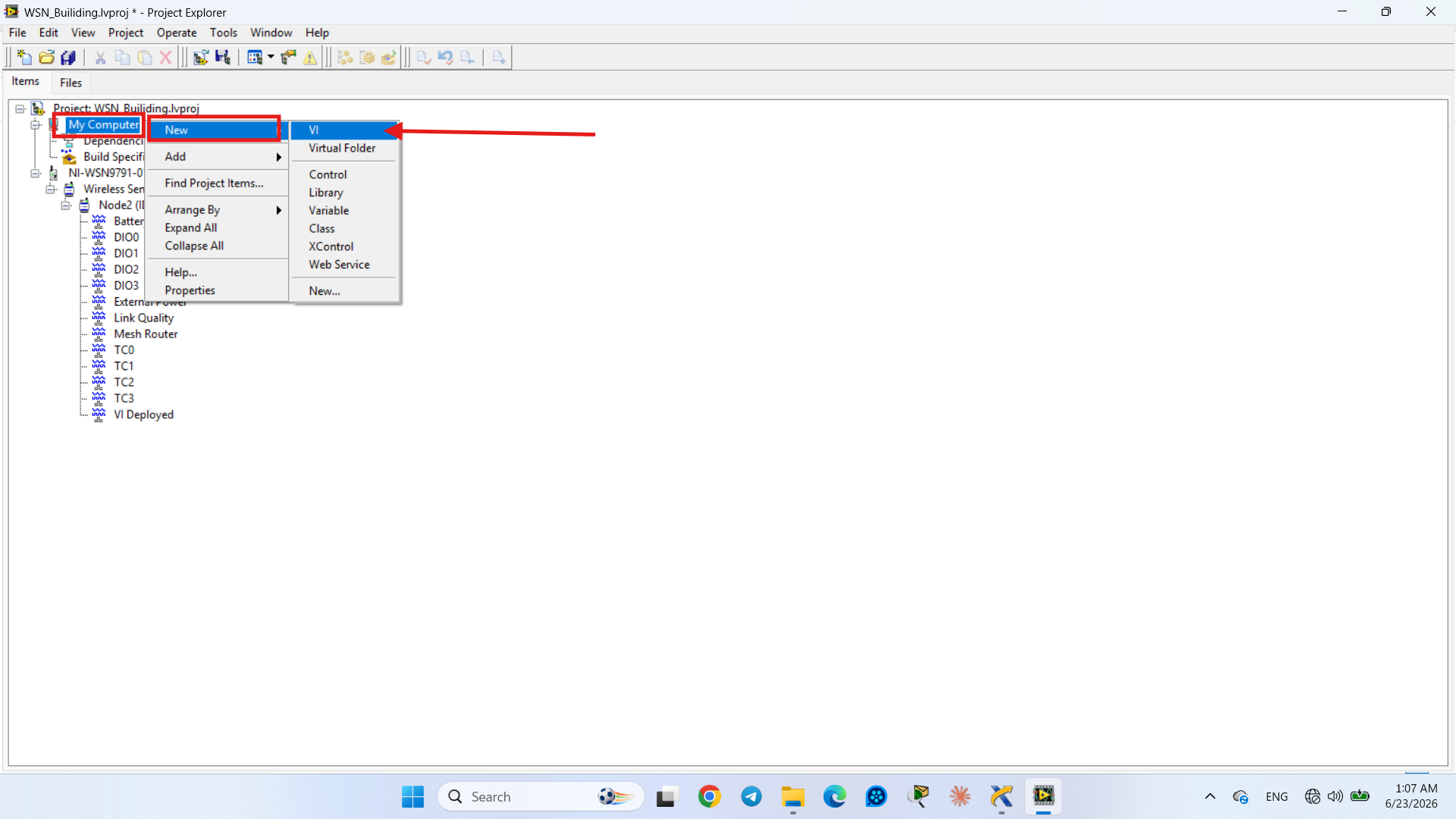
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XControl
Web Service
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Link Quality
Mesh Router
TC0
TC1
TC2
TC3
VI Deployed
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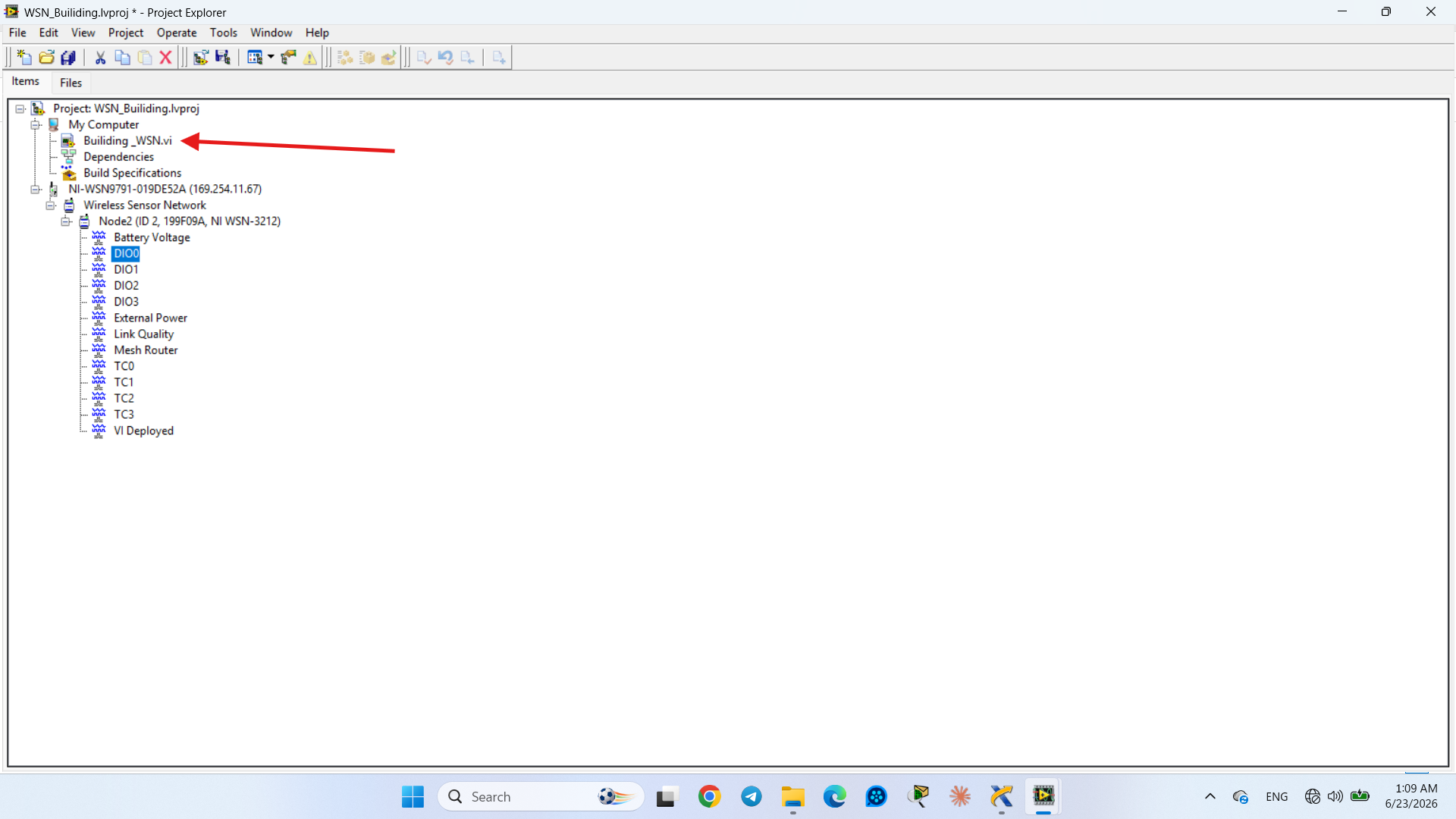
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Wireless Sensor Network
Node2 (ID 2, 199F09A, NI WSN-3212)
Battery Voltage
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DIO1
DIO2
DIO3
External Power
Link Quality
Mesh Router
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TC1
TC2
TC3
VI Deployed
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    - Build Specifications
  - NI-WSN9791-019DE52A (169.254.11.67)
    - Wireless Sensor Network
      - Node2 (ID 2, 199F09A, NI WSN-3212)
        - Battery Voltage
        - DIO0
        - DIO1
        - DIO2
        - DIO3
        - External Power
        - Link Quality
        - Mesh Router
        - TC0
        - TC1
        - TC2
        - TC3
        - VI Deployed

Builiding _WSN.vi Block Diagram on WSN_Builiding.lvproj/My Computer

File Edit View Project Operate Tools Window Help

15pt Application Font | Search

Functions | Search

Programming

Structures

Numeric

Comparison

File I/O

Synchronizat...

Measurement I/

Instrument I/O

Mathematics

Signal Processi

Data Communi

Connectivity

Express

Addons

Select a VI...

WSN Host API

Structures

For Loop | While Loop | Timed Struct...

Case Structure | Event Struct... | In Place Ele...

Flat Sequence | Stacked Seq...

Diagram Dis... | Conditional ... | Formula Node

Shared Varia... | Local Variable | Global Varia...

Decorations | Feedback No...

WSN_Builiding.lvproj/My Computer

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# System Intelligence

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Host Controller VI.vi Block Diagram *

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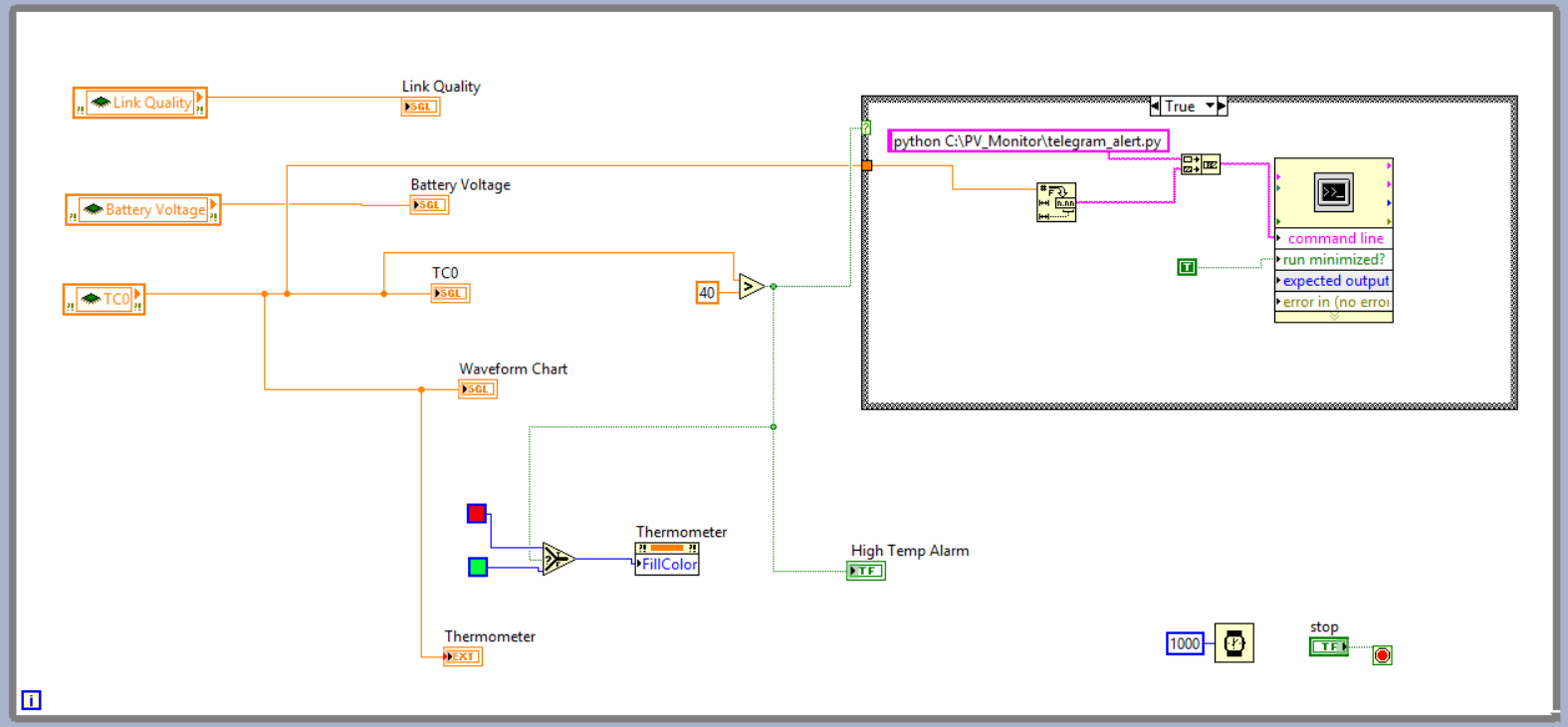


28°C مشمس غالبًا

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Host Controller VI.vi

File Edit View Project Operate Tools Window Help

# Wireless Sensor Network (WSN) for Solar PV Thermal

stop

STOP

| Link Quality | Battery Voltage | TC0 |
|---|---|---|
| 96 | 5.4 | 31.3296 |

High Temp Alarm

Thermometer

100 80 60 40 20 0

Waveform Chart

Plot 0

1E+10 0 -1E+10 -2E+10 -3E+10 -4E+10

Temperature

198 298

Time(sec)

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Host Controller VI.vi

File Edit View Project Operate Tools Window Help

# Wireless Sensor Network (WSN) for Solar PV Thermal

stop

STOP

Link Quality 99

Battery Voltage 5.3

TC0 31.1241

High Temp Alarm

Thermometer

100 80 60 40 20 0

Waveform Chart

Plot 0

31.35 31.3 31.25 31.2 31.15 31.1 31.05

Temperature

0 100

Time(sec)

28°C مشمس غالبًا

Search

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File Edit Selection View Go Run ···
Search
Sign In
Restricted Mode is intended for safe code browsing. Trust this window to enable all features. Manage Learn More

telegram_alert.py 1

C: > PV_Monitor > telegram_alert.py > ...

```python
import sys
import requests
import winsound

TOKEN = "7989281919:AAGiOJDrP7zOJB7icaGd62d1OiwQ-cT0wdE"
CHAT_ID = "-1004306465217"

if len(sys.argv) > 1:
    temp = float(sys.argv[1])

    if temp > 35:
        # رسالة احترافية تدعم العربية والإنجليزية
        msg = (
            f"🚨 <b>WSN Temperature Alert | إنذار درجة الحرارة</b>\n\n"
            f"<b>Current Reading:</b> {temp}°C | <b>القراءة الحالية:</b> {temp}°C\n"
            f"<b>Threshold:</b> 35°C | <b>الإنذار حد:</b> 35°C\n"
            f"<b>Project:</b> Wireless Sensor Network (WSN) | <b>المشروع:</b> شبكة الاستشعار اللاسلكية\n"
            f"<b>Status:</b> ⚠️ High Temperature | <b>الحالة:</b> درجة حرارة مرتفعة"
        )

        url = f"https://api.telegram.org/bot{TOKEN}/sendMessage"
        winsound.Beep(2500,800)
        requests.post(url, json={"chat_id": CHAT_ID, "text": msg, "parse_mode": "HTML"})
        print("✅ Alert Sent | تم إرسال الإنذار")
    else:
        print("✅ Normal Temperature | درجة حرارة عادية")
```

Restricted Mode ⊗ 0 ⚠ 1 Ln 10, Col 5 Spaces: 4 UTF-8 CRLF { } Python
Search
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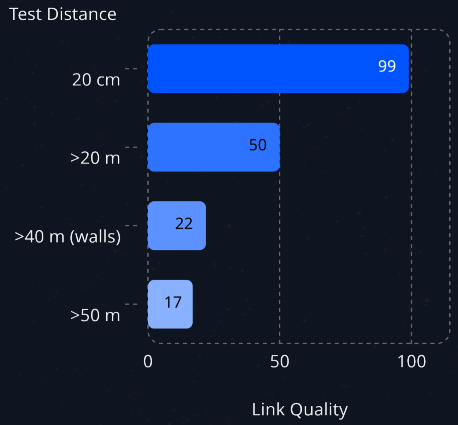
# Range Testing & Results




## Link Quality vs. Distance

Signal degrades sharply beyond 20 m and through walls. Excellent quality maintained at close range.

## Live Readings

TC0 = 56.08 °C · TC1 = 25.45 °C · Soil moisture AI0 = 0.949

## Telegram Alert

54.76 °C reported against 35 °C threshold — delivered in real time.

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Wireless Sensor Netw

7 أعضاء

🚨 **WSN Temperature Alert | إنذار درجة الحرارة**

**Current Reading:** 54.756229°C | **القراءة الحالية:** 54.756229°C

**Threshold:** 35°C | **حد الإنذار:** 35°C

**Project:** Wireless Sensor Network (WSN) | **المشروع:** شبكة الاستشعار اللاسلكية

**Status:** ⚠️ High Temperature | **الحالة:** درجة حرارة مرتفعة

4:39 م

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# Conclusion & Key Takeaways

**1** **End-to-End WSN System**

From theory to working hardware — gateway, nodes, and LabVIEW dashboard fully operational.

**2** **Real-Time Telegram Alerts**

Threshold breaches trigger instant mobile notifications with audible alerts.

**3** **Mathematical Foundation**

Formal optimization model with objectives, constraints, and numerical case study.

**4** **Scalable Architecture**

Star topology with NI WSN platform — extensible to additional sensor nodes and clusters.